NATIONAL BUREAU OF STANDARDS REPORT

7506

PERFORMANCE TEST OF A "DUSTFOE"
DISPOSABLE AIR FILTER

manufactured by
Mine Safety Appliances Company
Pittsburgh, Pennsylvania

by

Carl W. Coblentz and Paul R. Achenbach

Report to

General Services Administration
Public Buildings Service
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (Includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

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Mechanical Systems Section
Building Research Division

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1. Introduction

At the request of the Federal Supply Service, General Services Administration, the performance characteristics of a Dustfoe disposable air filter manufactured by the Mine Safety Appliances Company of Pittsburgh, Pennsylvania, were determined. The scope of this examination included the determination of the arrestance of the particulate matter in the laboratory air, the pressure drop and the dust holding capacity of the test specimen at the rated air flow rate of 1,000 cfm.

2. Description of Test Specimen

The test specimen was manufactured and supplied for test purposes by the Mine Safety Appliances Company of Pittsburgh, Pennsylvania. The outside dimensions of the filter unit were 23 1/4 in. square by 5 7/8 in. deep, its weight was 5,355 g (about 11 1/2 lbs.). Four pieces of hard fiber board, each about 23 in. long, 5 7/8 in. wide, and 1/4 in. thick formed a rigid box frame with sheet metal angles as corners. The filter media was arranged in 46 pleats that were supported by a wire framework. The media was cemented to the inside of the box frame. The total area of the filter media was approximately 75 sq ft and it consisted of a loose glass fiber paper that was supported on both sides by a 10-mesh webbing of a stiff organic fiber thread which did not sustain combustion.

The test specimen was operated at its rated air flow rate of 1,000 cfm. Based on a gross face area of 3.75 sq ft, this air flow rate corresponded to a face velocity of 267 ft/min, or with reference to the 75 sq ft of filter media installed in the filter to an average media face velocity of approximately 13.3 ft/min.

3. Test Method and Procedure

The arrestance measurements were made in accordance with the "NBS Dust Spot Method" described in a paper by R. S. Dill and entitled "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938).

For test purposes, the filter element was installed in the test apparatus and carefully sealed to prevent inward leakage of air except through the measuring orifice. The desired rate of air flow through the filter was established and samples of air were drawn from the center points of the test duct two feet upstream and eight feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The change of the opacity of these areas was determined with a sensitive photometer which measured the light transmission of the same spot on each sampling paper before and after the test. The two sampling papers used for each test were selected to have the same light transmission readings when clean.

All but one of the arrestance determinations were made using the particulate matter in the laboratory air as the aerosol. For these tests equal sampling areas were used for the upstream and downstream samplers. A similar increase of the opacity of the upstream and downstream filter papers was obtained by passing the sampling air through the upstream paper only part of the time while operating the downstream sampler continuously. This was accomplished by installing one solenoid valve in the upstream sampling line and another one as a by-pass for the sampler and first solenoid valve. The valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, reversing the position of the two valves during the remainder of the cycle. The arrestance, A (in percent), was then determined with the following formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, ΔU and ΔD being the changes of opacity of the sampling papers, as previously indicated.

For determining the arrestance of the filter, with Cottrell precipitate as the test dust, different size areas of sampling papers were used upstream and downstream of the filter in order to obtain a similar increase of opacity on both sampling papers.

For each arrestance determination with Cottrell precipitate, the upstream sample of the aerosol was collected on one filter paper for about half of the test period and on a second filter paper during the remainder of the test period. The downstream sampling paper collected the dust for the entire test. This method was used to avoid too large differences in the dust spots when determining Cottrell precipitate arrestance values

Table 1

PERFORMANCE OF A MINE SAFETY APPLIANCES COMPANY
"DUSTFOE" DISPOSABLE AIR FILTER
AT AN AIR FLOW RATE OF 1000 CFM

Dust Load g	Pressure Drop in. W.G.	Arrestance %
0	0.415	85.0
0	0.417	84.6
15	0.437	98.9*
99	0.587	88.8
158	0.700	89.4
238	0.901	--
257	0.989	92.2
257	1.20	94.1

*Cottrell precipitate was used as the aerosol in this test, all other arrestance determinations were made using the particulate matter in the laboratory air as the aerosol.

on the order of 99 percent. The arrestance, A (in percent), was then calculated by the formula:

$$A = \left(1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U_1 + \Delta U_2}\right) \times 100$$

where S_U and S_D are the upstream and downstream sampling areas and ΔU_1, ΔU_2, and ΔD the observed changes in the opacity of the two upstream and one downstream sampling papers, respectively.

After making two arrestance determinations with the particulate matter in the laboratory air as the aerosol, one arrestance determination was made with Cottrell precipitate. The specimen was then loaded with Cottrell precipitate and lint at a rate of 1 gram of dust per 1,000 cu ft of air. Cotton lint was added during the loading process in a ratio of 4 parts to every 96 parts by weight of Cottrell precipitate, including the amount used for the one arrestance measurement. The Cottrell precipitate was previously sifted through a 100-mesh screen and the lint was prepared by grinding No. 7 cotton linters in a Wiley mill with a 4-millimeter screen.

Four more arrestance determinations were made at selected intervals with the particulate matter in the laboratory air as the aerosol. The pressure drop across the filter was recorded at the beginning and at the end of each arrestance determination and also after introducing each increment of 20 grams dust into the test apparatus. The test was terminated when the pressure drop exceeded 1 in. W.G.

4. Test Results

The test results are summarized in Table 1 which shows the pressure drop across the filter and the arrestance values determined at several dust load conditions.

The "Dust Load" shown in this table is the weight of Cottrell precipitate and lint received by the filter. It is the total aerosols introduced into the test apparatus diminished by the percentage of fallout upstream of the filter. This dust fallout was determined at the conclusion of the test by sweeping out the test duct on the approach side of the test specimen. The fallout amounted to 13 grams, or 4.8 percent of the total 270 g of Cottrell precipitate and lint introduced into the test apparatus during the test.

It will be noted that the arrestance of the particulate matter in the laboratory air increased from about 85 percent to 94 percent while the filter received a dust load of 257

grams. Only one arrestance determination was made with Cottrell precipitate as the aerosol indicating almost 99 percent with a clean filter. The pressure drop of the clean filter was 0.415 in. W.G.

Figure 1 presents a graph of the values shown in Table 1 with the pressure drop and the arrestance values plotted against the dust load. Smooth curves were drawn through the plotted points representing the observed data. This graph shows that the pressure drop increased in almost direct proportion to the dust load until more than 200 grams had been introduced and then rose very sharply. This rise in pressure drop coincides with a sudden rise of approximately 3 percent in the observed arrestance. This sudden rise in pressure drop and increase in arrestance occurred during a period of about 2 hours in which an atmospheric arrestance determination was being made and no additional Cottrell precipitate was added.

According to these graphs, the dust load at 1.00 in. W.G. pressure drop was 255 grams and the average arrestance approximately 89 percent.

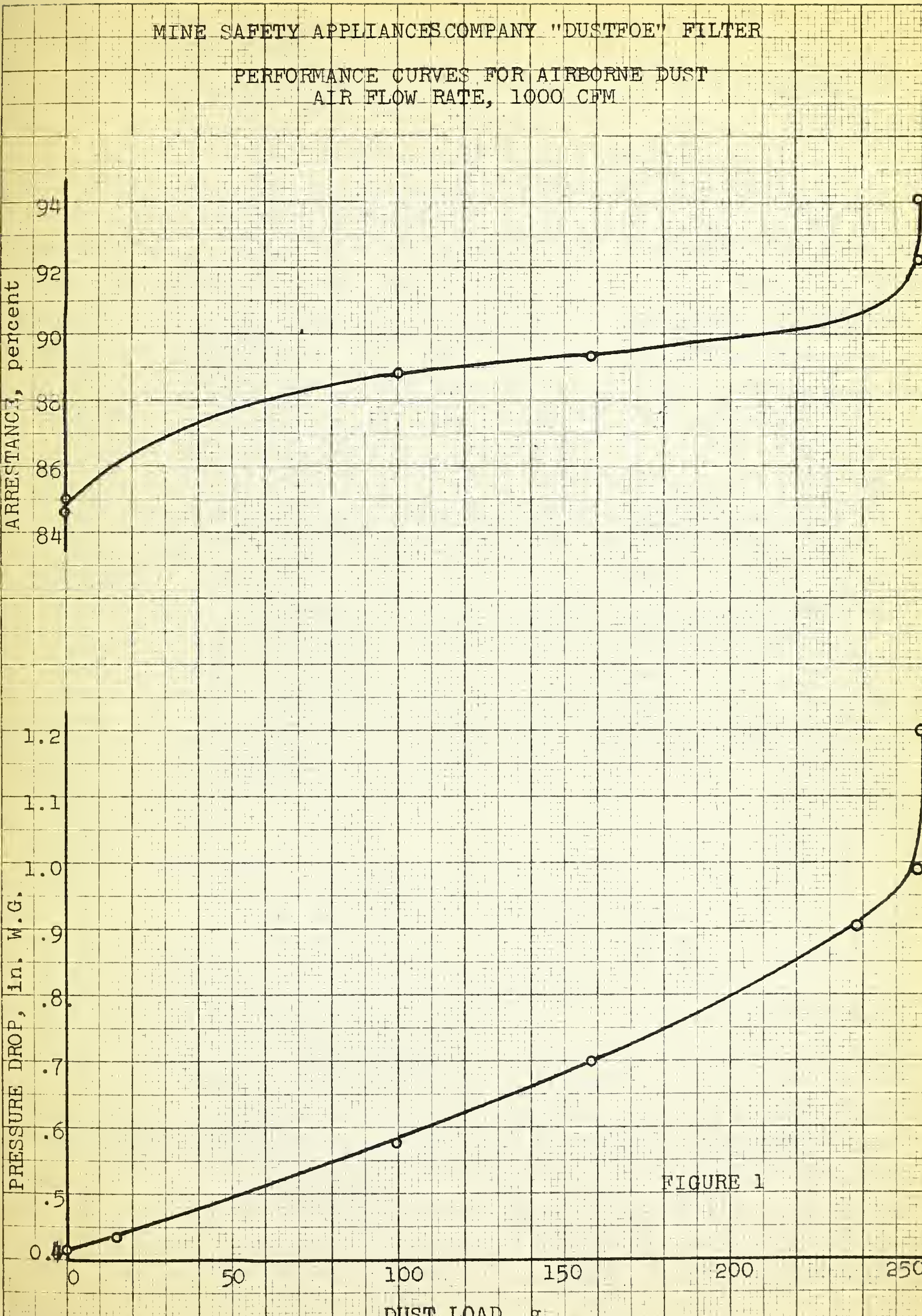
MINE SAFETY APPLIANCES COMPANY "DUSTFOE" FILTER
PERFORMANCE CURVES FOR AIRBORNE DUST
AIR FLOW RATE, 1000 CFM
ARRESTANCE, percent
84
86
88
90
92
94
PRESSURE DROP, in. W.G.
0.4
.5
.6
.7
.8
.9
1.0
1.1
1.2
0
50
100
150
200
250
DUST LOAD, g

FIGURE 1

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Microscopy and Diffraction. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Solid State Physics. Electron Physics. Atomic Physics.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Molecular Kinetics. Mass Spectrometry.

Office of Weights and Measures.

BOULDER, COLO.

Cryogenic Engineering Laboratory. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Cryogenic Technical Services.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Millimeter-Wave Research.

Circuit Standards. High Frequency Electrical Standards. Microwave Circuit Standards. Electronic Calibration Center.

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